DISRUPTING ILLEGAL FIREARMS MARKETS IN BOSTON: THE EFFECTS OF OPERATION CEASEFIRE ON THE SUPPLY OF NEW HANDGUNS TO CRIMINALS*

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Research Summary:
The question of whether the illegal firearms market serving criminals and juveniles can be disrupted has been vigorously debated in policy circles and in the literature on firearms and violence. To the extent that prohibited persons, in particular, are supplied with guns through systematic gun trafficking, focused regulatory and investigative resources may be useful in disrupting the illegal supply of firearms to criminals. In Boston, a gun market disruption strategy was implemented that focused on shutting down illegal diversions of new handguns from retail sources. Multivariate regression analyses were used to estimate the effects of the intervention on new handguns recovered in crime. Our results suggest that focused enforcement efforts, guided by strategic analyses of ATF firearms trace data, can have significant impacts on the illegal supply of new handguns to criminals.

Policy Implications:
The problem-oriented policing approach provides an appropriate framework to uncover the complex mechanisms at play in illicit firearms markets and to develop tailor-made interventions to disrupt the

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illegal gun trade. Strategic enforcement programs focused on the illegal diversion of new firearms from primary markets can reduce the availability of new guns to criminals. However, the extent to which criminals substitute older guns for new guns and move from primary markets to secondary markets in response to an enforcement strategy focused on retail outlets remains unclear. Our evaluation also does not provide policy makers with any firm evidence on whether supply-side enforcement strategies have any measurable impacts on gun violence. Jurisdictions suffering from gun violence problems should implement demand-side violence prevention programs to complement their supply-side efforts.

KEYWORDS: Gun Markets, Gun Crime, Supply Reduction, Problem-Oriented Policing

In the United States, there are some 258 million privately owned firearms, including 93 million handguns (Wellford et al., 2005). This immense stockpile serves as a source of guns to juveniles and other prohibited persons, who may obtain them through a variety of means. Although there is much debate about proper gun control measures to reduce legal access to guns, insufficient emphasis is placed on the fact that only about one of every six firearms used in crime was legally obtained (Reiss and Roth, 1993). Unlike narcotics or other contraband, the illegal supply of guns does not begin with illegal smuggling or in clandestine factories. Virtually every crime gun in the United States starts out, at least initially, in the legal market. Clearly, there is a problem with illegal gun acquisition from regulated and unregulated legal sources, and there is a corresponding need to intervene in these markets to make it more expensive, inconvenient, or legally risky to obtain firearms for criminal use.

The pervasiveness of guns in the United States suggests to some that it is simply not feasible to prevent people barred by law from possessing firearms from obtaining them if they are so inclined. Supply-side enforcement strategies seems futile if one accepts the common view that "guns are everywhere," and almost anyone can quickly and cheaply obtain a gun regardless of age or place of residence (see, e.g., Wright, 1995). However, much evidence suggests that many active criminals and many crime-involved youth do not own a gun. For example, according to victim reports, 75% of robbers do not use a gun despite the tactical advantage of doing so (Cook and Leitzel, 1996). A longitudinal study of teenage gang members in Rochester, New York, found that only one third owned a gun (Bjerregaard and Lizotte, 1995). Similarly, one third of juvenile male arrestees in 11 cities reported owning a gun (Decker et al., 1997). Some policy analysts suggest that, even in gun-rich environments, supply-side efforts directed at

reducing access by those who are legally proscribed can be used to reduce the prevalence of gun possession and use by criminals and juveniles (see, e.g., Braga et al., 2002; Cook and Braga, 2001). Unfortunately, arguments for and against a market-based approach to reduce criminal gun use are largely based on speculation, not on research evidence (Wellford et al., 2005).

The U.S. Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) is charged with regulating firearms commerce and enforcing federal firearms law. Historically, with the support of local, state, and federal law-enforcement partners, ATF has pursued cases against armed career criminals and firearms traffickers. In 1996, the ATF intensified its efforts to address the illegal supply of guns by strategically using firearms trace data to identify gun traffickers (ATF 2000a; 2000b). Heightened enforcement of federal laws against illegal gun trafficking is also a major component of the current U.S. Department of Justice-sponsored Project Safe Neighborhoods initiative to reduce gun violence in each of the 94 U.S. Attorney judicial districts in the United States (http://www.psn.gov). Clearly, the U.S. Government has made large investments in disrupting illegal gun markets serving criminals. However, the National Academy of Sciences Committee to Improve Research Information and Data on Firearms concluded "it is simply not known whether it is actually possible to shut down illegal pipelines of guns to criminals nor the costs of doing so" (Wellford et al., 2005, p. 8).

This article represents a modest attempt to determine whether supply-side enforcement efforts can be used to shut down illegal pipelines of guns to criminals by evaluating the effects of the Operation Ceasefire gun market disruption strategy on the supply of new handguns to criminals in Boston. We find that focused enforcement efforts, guided by strategic analyses of ATF firearms trace data, can impact the segment of illegal markets supplied by recent diversions of guns from retail sources and significantly reduce the percentage of new handguns recovered in crime.

ILLEGAL GUN MARKETS AND THE PROSPECTS OF A SUPPLY-SIDE ENFORCEMENT STRATEGY

Legal firearms commerce comprises transactions made in the primary firearms market and in the largely unregulated secondary firearms market. Transactions of new and secondhand firearms conducted through Federal Firearms Licensees (FFLs) form the primary market for firearms (Cook et al., 1995). Retail gun stores sell both new and secondhand firearms and, in this regard, resemble automobile sales lots. Once a gun is in private hands, it can be transferred in a wide variety of ways such as through classified ads in newspapers and gun magazines, and at gun shows (which include

both licensed and unlicensed dealers). Transfers of secondhand firearms by unlicensed individuals form the secondary market, where no records are kept and criminal background checks are not required (Cook et al., 1995). About 30–40% of all gun transactions occur on the secondary market (Cook and Ludwig, 1996). Primary and secondary firearms markets are closely linked because many buyers move from one to the other depending on relative prices and other terms of the transaction (Cook and Leitzel, 1996). As regulations tighten in the primary market, Cook et al. (1995) suggest that the unregulated secondary market will become increasingly attractive.

Survey research suggests that theft from private citizens is an important source of firearms for criminals (Bureau of Justice Statistics, 1993; Sheley and Wright, 1995; Wright and Rossi, 1994). However, analyses of ATF firearms trace data and ATF firearms trafficking investigation data reveal that illegal diversions of firearms from retail businesses are also important sources of crime guns (see, e.g., Braga and Kennedy, 2001; Kennedy et al., 1996; Moore, 1981; Pierce et al., 1995; Wachtel, 1998). Through crime gun tracing, trace analysis, investigative work, and the help of outside researchers, the ATF has developed a more refined picture of the complex illegal firearms market that supplies guns to proscribed persons. The components of the market include: trafficking in new firearms, interstate and intrastate, by licensed firearms dealers (FFLs including pawnbrokers), large-scale straw purchasers or straw purchasing rings, and small-scale straw purchasers (i.e., legally entitled purchasers buying one or a few guns for prohibited persons); trafficking in secondhand firearms, interstate and intrastate, by licensed firearms dealers (including pawnbrokers), large-scale straw purchasers or straw purchasing rings, small-scale straw purchasers (i.e., buying one or a few guns), unregulated private sellers (operating at gun shows and flea markets, through want ads, the Internet, and personal associations), and bartering and trading within criminal networks; and trafficking in new and used stolen firearms involving theft from licensed dealers and pawnbrokers, organized fencing of stolen guns, common carrier (such as the United Parcel Service) theft, manufacturer theft, and household theft (ATF, 2000a; 2000b).

Survey estimates based on inmate surveys suggest that, as an upper bound, almost half of all crime guns may be diverted to offenders through theft (see, e.g., Wright and Rossi, 1994). Conversely, it suggests that at least half of crime guns make their way to offenders through one or a series of non-theft primary and/or secondary market transactions. Judging the importance of illegal diversions from the primary and secondary markets relative to one another is difficult with available data. Analyses of firearms trace data indicate that new firearms are more likely to be used as

crime guns than are older firearms (see, e.g., Cook and Braga, 2001; Kennedy et al. 1996). A third of Wright and Rossi's (1994) male prison inmates reported that their most recently acquired handgun was new rather than used and 21% purchased their most recently acquired handgun from a retail outlet. The acquisitions from licensed dealers could have occurred in a variety of ways: buys from corrupt FFLs; theft from FFLs [3% of Wright and Rossi's (1994) respondents stole their most recent gun from a gun store]; buys from FFLs through fraudulent means, including straw purchases, the use of fake identification, or the provision of false information about buyer eligibility; or legal buys from FFLs (some respondents may have had clean records at the time of their most recent purchase). Thus, existing research indicates that illegal diversions from both the primary and the secondary market are important sources of guns for prohibited users.

THE PROSPECTS OF SUPPLY-SIDE ENFORCEMENT

In their review of the various sources of data on the illegal supply of firearms, Braga et al. (2002) suggest that, in the parlance of environmental regulation, illegal gun markets consist of both "point sources"—ongoing diversions through scofflaw dealers and trafficking rings—and "diffuse sources"—acquisitions through theft and informal voluntary sales. A reasonable conclusion is that, as in the case of pollution, both point sources and diffuse sources are important (see also Cook and Braga, 2001). Braga et al. (2002) also speculate that the mixture of point and diffuse sources differs across jurisdictions and depends on the density of gun ownership and the strictness of gun controls. For example, systematic gun trafficking from retail point sources may be more difficult in jurisdictions with stricter controls on the purchase and sale of firearms such as Boston and New York than in looser control jurisdictions such as Atlanta and Dallas. Given that there is a mixture of concentrated and diffuse sources, the potential effectiveness of supply-side enforcement may also vary across jurisdictions.

Effective supply-side efforts could help increase the price of guns sold to prohibited persons and increase the "effective price" of acquiring guns—the time and hassle required to make a "connection" to buy guns (see Moore, 1973; 1976). The benefit of this approach would be an increased incentive for criminals and youth to economize on gun possession and use. As guns become scarcer and more valuable, they will be slower to buy and quicker to sell. Thus, prohibited persons would possess guns for smaller amounts of time over the course of their criminal careers (Kennedy, 1994). Unfortunately, there is little direct evidence that successful regulatory and enforcement actions against point and diffuse sources will actually reduce availability and hence gun use in crime. More research on the structure of

illegal gun markets and experimentation with market disruption tactics is sorely needed.

OPERATION CEASEFIRE AND DISRUPTING ILLEGAL GUN MARKETS IN BOSTON

The Boston Gun Project was a problem-oriented policing initiative expressly aimed at reducing homicide victimization among youths in Boston in the mid-1990s (Kennedy et al., 1996; 2001). It represented an innovative partnership between researchers and practitioners to assess the city's youth homicide problem and implement an intervention designed to have a substantial near-term impact on the problem. Project research showed that the problem of youth homicide was concentrated among a few chronically offending gang-involved youth (Kennedy et al., 1996). Project research also showed that firearms recovered from youth, especially with gang youth, tended to be semiautomatic pistols, often ones that were new and apparently recently diverted from retail (Kennedy et al., 1996). Many of these guns were first sold at retail in Massachusetts as well as being smuggled into Boston from out of state. The Project began in early 1995 and implemented what is now known as the "Operation Ceasefire" intervention beginning on May 15, 1996. The Ceasefire intervention had two main elements: (1) the "pulling levers" focused deterrence strategy to prevent gang violence, and (2) a direct law-enforcement attack on illicit firearms traffickers supplying youth with guns.

A National Institute of Justice (NIJ) sponsored evaluation found that the Ceasefire intervention was associated with a 63% reduction in Boston youth homicide and similar large reductions in nonfatal serious gun violence (Braga et al., 2001). The National Academies' Panel on Improving Information and Data on Firearms (Wellford et al., 2005) concluded that the Ceasefire evaluation was compelling in associating the intervention with the subsequent decline in youth homicide. However, the Panel also suggested that many complex factors affect youth homicide trends, and it was difficult to specify the exact relationship between the Ceasefire intervention and the subsequent changes in youth offending behaviors. Although the NIJ-sponsored evaluation controlled for existing violence trends and certain rival causal factors such as changes in the youth population, drug markets, and employment in Boston, there could be complex interaction effects among these factors not measured by the evaluation that could account for some meaningful portion of the decrease (for other critical appraisals, see Braga and Winship, 2005; Fagan, 2002; Levitt, 2004).

The NIJ-sponsored evaluators credited the "pulling levers" focused deterrence strategy with the sudden, large impact on youth homicide and gun violence. Their assessment that the principal impact was a demand-

side, deterrence-based effect, rather than a supply-side effect was based on two observations (Braga et al., 2001): First, it seemed implausible that supply-side efforts were responsible for the abrupt reductions in gun-related violence over the summer of 1996. Boston trafficking cases followed that reduction, rather than anticipated it. Second, anti-trafficking efforts in Boston did nothing to reduce the existing stockpile of illegally acquired and possessed firearms in Boston. Those guns held by gang members in Boston in May of 1996 were, for the most part, still held by them several months later when the violence reached its new, lower equilibrium. The immediate change that occurred was not in the extent of gun ownership, but in gun use. Although it was unlikely that Ceasefire's gun market disruption strategies had a meaningful short-term impact on serious gun violence, it remained an open-ended question of whether the intervention had a meaningful longer term impact on the illegal supply of guns to criminals and youth in Boston.

THE ILLEGAL FIREARMS MARKET SERVING YOUTH IN BOSTON

Boston Gun Project research initially focused on understanding and addressing the local illicit firearms market serving youth aged 21 years and younger.[1] Youth gun acquisition was largely driven by fear, self-protection, and status concerns originating from a high-risk street environment dominated by violent gangs, drugs, and guns (Kennedy et al., 1996). Interviews with youth probationers in Boston revealed that guns were fairly easy to acquire either by buying them illegally or by borrowing them from friends and associates (Kennedy et al., 1996). For style reasons and to avoid being caught with an older gun that may have already been used in a violent crime, youth probationers expressed a strong preference for "new in the box" semiautomatic pistols.

To unravel the nature of the illegal gun market, the Boston Gun Project research team analyzed ATF firearms trace data for 1,550 firearms recovered from youth aged 21 years and under in Boston between January 1991 and May 1995 (Kennedy et al., 1996). Some 82% of the recovered firearms were handguns, and more than half were semiautomatic pistols. Recovered semiautomatic pistols were concentrated among a few calibers, such as 9 mm, .380, and .25, and a small number of low-quality manufacturers, such as Raven, Davis, Bryco/Jennings, and Lorcin. Overall, 52% of the

1. Over the course of the Boston Gun Project, the target age group evolved from "juveniles ages 17 and under" to "youth ages 21 and under" to "youth ages 24 and under" as the research team unraveled the nature of Boston's youth gun violence problem (Kennedy et al., 2001). The problem analysis research revealed that gangs, largely comprised by youth aged 24 years and under, were central to ongoing gun violence in Boston.

firearms recovered from youth were successfully traced to their first retail sale. Almost 20% of recovered youth guns were not traced because of obliterated serial numbers. According to the ATF, guns recovered with obliterated serial numbers are likely to be trafficked because defacing serial numbers represents an attempt to avoid identification of the retail purchaser though existing purchase and sales records (ATF, 2000b). An analysis of the source states of traceable guns revealed that Boston had both a problem with diversion from local licensed dealers and a problem with "southern pipeline" firearms. Despite strict state controls on firearms commerce, 34% of traceable guns were first sold at retail in Massachusetts. Nearly 32% of traceable firearms were first sold at retail in loose-control southern states, most notably, in the I-95 states of Florida, Georgia, Virginia, North Carolina, and South Carolina.

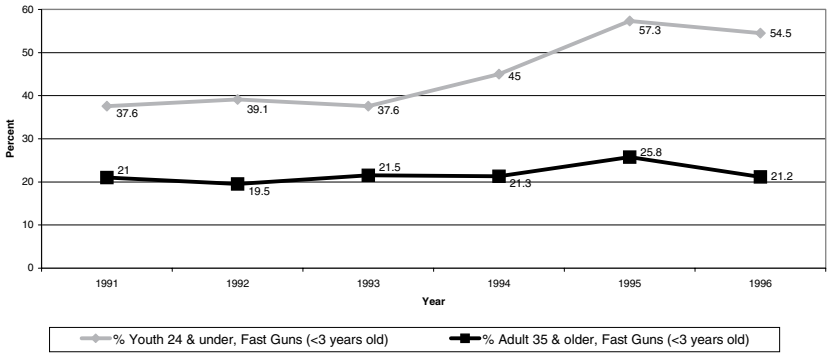
The time between a firearm's first sale at retail and subsequent recovery in crime is popularly known as "time-to-crime" (Pierce et al., 2004). Law-enforcement investigators consider that a short time-to-crime, defined by ATF as three years or less, suggests that a firearm may have been recently illegally diverted from retail outlets (ATF, 2002). Overall, 35% of traceable Boston youth guns were new guns. For all traceable new firearms, the first retail purchaser was a different person than the youth from whom the gun was recovered, which suggests a recent illegal diversion from legitimate firearms commerce. Before Ceasefire was implemented, new handguns represented an increasing proportion of traceable handguns recovered from Boston youth aged 24 years and younger (Figure 1).[2] New handguns recovered from adult gun offenders, aged 35 years and older, do not exhibit the same trend. It suggests that youth demand for new handguns was easily supplied through illegal diversion of guns from retail sources, and new handguns accounted for an increasing bulk of the stockpile of guns in the hands of Boston youth over time.

OPERATION CEASEFIRE'S GUN MARKET DISRUPTION STRATEGY

The interagency Boston Gun Project working group developed a gun market disruption strategy to address the patterns of illegal diversion identified by the research. The resulting strategy was appropriately focused on the illegal diversion of new handguns from retail outlets in Massachusetts and elsewhere. For investigative and tactical purposes, guns with quick time-to-crime offer law enforcement an opportunity to identify illegal gun traffickers. New guns have passed through fewer hands, and this makes it much easier for law enforcement to investigate its diversion and its

2. These data were not part of the original Boston Gun Project research.

FIGURE 1. NEW HANDGUNS RECOVERED FROM BOSTON YOUTH AND ADULTS, 1991–1996



diverters, and to mount prosecutions. Records are likely to be more complete and more available; individuals listed on paperwork are easier to find; guns are less likely to have been resold, given away, or stolen; and the chain of transfers to illicit consumers is likely to be shorter (Kennedy et al., 1996). Although youth handguns were given investigative priority, the gun-trafficking initiative was intended to reduce the general availability of new handguns to all gun-using criminals in Boston, regardless of possessor age. The key elements of the Ceasefire gun market disruption strategy were as follows (summarized from Kennedy et al., 2001):

- Expanded focus of local, state, and federal authorities to include intrastate firearms trafficking in Massachusetts in addition to interstate trafficking.
- Focused enforcement attention on traffickers of the makes and calibers of handguns most used by gang members.
- Focused enforcement attention on traffickers of handguns that had short time-to-crime intervals and, thus, were most likely to have been trafficked. The ATF Boston Field Division implemented an in-house tracking system that flagged handguns whose traces revealed a short time-to-crime interval.
- Focused enforcement attention on traffickers of handguns used by the city's most violent gangs.
- Attempted to restore obliterated serial numbers of confiscated handguns and subsequently to investigate trafficking based on these restorations.
- Supported these enforcement priorities through strategic analyses of data generated by the Boston Police Department and ATF's comprehensive tracing of crime guns and by developing leads from

the systematic debriefing of gang-affiliated arrestees and those involved in violent crime.

- Deliberate communication of successful investigations and prosecutions of gun traffickers to deter others from diverting firearms from retail sources to criminals and youth in Boston.[3]

Operation Ceasefire's "pulling levers" deterrence strategy, as designed, was in place until Spring 2000 (Braga and Winship, 2005). Unlike the now-defunct gang violence reduction strategy, the Boston Police Department, ATF Boston, and the U.S. Attorney's Office continued their focus on identifying, apprehending, and prosecuting illegal gun traffickers. Table 1 presents a summary of 370 ATF gun-trafficking investigations made by the ATF Boston Field Division between June 1996 and December 2003.[4] A wide variety of gun-trafficking enterprises were investigated. Half of the investigations involved firearms trafficking by straw purchasers, nearly 24% involved firearms trafficking by unlicensed dealers, and only 2.7% involved firearms trafficking by a licensed dealer. Overall, 62.4% of the investigations involved the illegal diversion of new guns and 63% involved the illegal diversion of secondhand firearms. Almost 71% of the investigations involved intrastate diversions of firearms, and nearly 53% involved interstate diversions of firearms. These 370 investigations involved the illegal diversion of 6,124 firearms (mean of 16.6 guns per investigation ranging from a minimum of one gun to a maximum of 325 guns). By January 2004, ATF agents had recommended 306 (82.7%) of the investigations for prosecution. These 306 recommendations resulted in 515 defendants being charged in federal, state, and local courts. Overall, 250 of the defendants have been fully adjudicated (48.5% of 515) and 246 were convicted of their crimes (98.4%).

3. See Kennedy et al., 2001 on the marketing of the Ceasefire deterrence message. Local newspapers also regularly published articles on gun trafficking enforcement efforts in Boston. See, e.g., Matthew Taylor, "Quincy Man Held For Selling Illegal Weapons; Tied to Gangs." *The Boston Globe*, November 28, 1996, p. B4; New England News Brief, "Man Charged With Illegally Selling Guns." *The Boston Globe*, July 28, 2000, p. B4; New England News Brief, "Roxbury Man Ordered Held in Weapons Case." *The Boston Globe*, November 16, 2002, p. B2; and Ric Kahn, "Ex-Boston Gang Member Guilty of Gun Charges Down South." *The Boston Globe*, February 8, 2004, p. 1.

4. These data were collected as part of an ATF-sponsored project to monitor their gun trafficking enforcement initiatives (ATF, 2000a). Gun trafficking investigations can be complex and involve a variety of sources of illegal guns. For example, a corrupt FFL could illegally sell both new and secondhand firearms at his business premises and at gun show locations to straw purchasers and prohibited persons who use false identification. As such, the various categories presented in Table 1 are not mutually exclusive.

TABLE 1. GUN-TRAFFICKING INVESTIGATIONS INITIATED BETWEEN JUNE 1996 AND JUNE 2003 BY THE ATF BOSTON FIELD DIVISION

Illegal Source of Guns Investigated	N	Percent
Firearms diverted by straw purchaser or straw purchasing ring	185	50.0%
Firearms diverted by unlicensed dealers	87	23.5%
Diverting firearms stolen from residence	57	15.4%
Prohibited persons "lying and buying" firearms	53	14.3%
Diverting firearms stolen from licensed dealer	36	9.7%
Diverting firearms at gun shows or flea markets	14	3.8%
Firearms diverted by licensed dealer	10	2.7%
Diverting firearms stolen from common carrier	5	1.4%
Diverting firearms over the Internet	4	1.1%
Diversion of new guns	231	62.4%
Diversion of secondhand guns	233	63.0%
Interstate diversion	195	52.7%
Intrastate diversion	262	70.8%

N = 370 investigations.
NOTE: Sum may exceed 100% because investigations may be included in more than one category.

DATA AND METHODS

Like most evaluations of crime-prevention programs (Ekblom and Pease, 1995), our evaluation design departs from the desirable randomized controlled experimental approach. The Ceasefire gun market disruption strategy was aimed at impacting the illegal trade in new handguns in all areas of Boston. There were no control areas set aside within the city because of the following: (1) An illicit point source of new guns, such as a corrupt licensed dealer, could be exploited by multiple gun criminals and gang-involved youth throughout the city; (2) diffuse sources, such as small-scale straw purchasers and street fences who sometimes sell guns, could transfer illegal guns that are used by criminals and gang-involved youth in multiple areas of the city, and (3) the communications strategy was explicitly designed to deter gun traffickers and gun criminals not specifically targeted by enforcement actions from acquiring guns from retail sources. Therefore, it was not possible to compare the age of handguns recovered in areas affected by the strategy with the age of handguns recovered in similar areas not affected. Our analysis of impacts within Boston associated with the Ceasefire intervention follows a basic one-group time-series design (Campbell and Stanley, 1966; Cook and Campbell, 1979); ATF firearms trace data are used to measure Ceasefire effects on the percentage of recovered handguns that were new in Boston over time. We also use a nonrandomized post-test-only comparison design to compare trends in ATF firearms trace data for gun recoveries in Boston with trends in ATF

firearms trace data for gun recoveries in 14 other large U.S. cities (Cook and Campbell, 1979).

FIREARMS TRACE DATA

The Gun Control Act (GCA) of 1968 established a set of requirements that allowed for the chain of commerce for any given firearm to be traced from its manufacture or import through its first sale by a retail dealer (Cook and Braga, 2001; Wellford et al., 2005; Zimring, 1975). Each new firearm, whether manufactured in the United States or imported, must be stamped with a unique serial number. Manufacturers, importers, distributors, and FFLs are required to maintain records of all firearms transactions, including sales and shipments received. FFLs must report multiple handgun sales and stolen firearms to ATF and provide transaction records to ATF in response to trace requests. When FFLs go out of business, they are to transfer their transaction records to ATF, which then stores them for tracing (ATF, 2000b). In essence, the 1968 GCA created a paper trail for gun transactions that can be followed by ATF agents.

The tracing process begins with a law-enforcement agency's submission of a trace request to ATF's National Tracing Center (NTC). The form requires information regarding the firearm type (pistol, revolver, shotgun, rifle, etc.), the manufacturer, caliber, serial number, and importer (if the gun is of foreign manufacture), the location of the recovery, the criminal offense associated with the recovery, and the name and date of birth of the firearm possessor (ATF, 2000b). This information is entered into the ATF's Firearms Tracing Center at the NTC and checked against the records of out-of-business FFLs that are stored by the ATF, and records of multiple handgun purchases reported on an ongoing basis by FFLs. If the gun does not appear in these databases, the NTC contacts the firearm manufacturer (for domestic guns) or the importer (for foreign guns) and requests information on the distributor that first handled the gun. The ATF then follows the chain of subsequent transfers until it identifies the first retail seller. That FFL is then contacted with a request to search his or her records and provide information on when the gun was sold and to whom.

Research studies based on analyses of firearms trace data must take into consideration the potential problems with the scope and quality of these data. Trace data analyses are subject to several widely recognized problems (see Blackman, 1999; Congressional Research Service, 1992; Kleck, 1999). All are based on firearms recovered by police and other law-enforcement agencies, which may not be representative of firearms possessed and used by criminals. Trace data sets are also influenced by which guns are submitted for tracing, a decision made by law-enforcement agencies.

It is important to note that, even when a trace is "successful," it provides limited information about the history of the gun (Cook and Braga, 2001). Most successful gun traces only access the data on the dealer's record for the first retail sale of the gun. Generally, subsequent transactions cannot be traced from the sorts of records required by federal firearms laws. More centrally, trace analysis cannot show directly whether a firearm has been trafficked. Trace studies typically contain information about the first retail sale of a firearm and about the circumstances associated with its recovery by law enforcement. These studies cannot directly show what happened in between: whether a firearm was legitimately purchased and subsequently stolen, sold improperly by a licensed dealer, or any other of a myriad of possibilities. As such, trace analysis cannot directly show that trafficking is occurring.

Nevertheless, the quality of firearms trace data has improved significantly over the past decade. From the beginning in 1993, the Clinton Administration was concerned about the apparent ease with which criminals and juveniles obtained guns. The ATF was charged with initiating a concerted effort to increase the amount of crime gun tracing, improve the quality of firearms trace data, increase the regulation of gun dealers, educate law enforcement on the benefits of tracing, and increase investigative resources devoted to gun traffickers (Cook and Braga, 2001). Comprehensive tracing of all firearms recovered by police is a key component of the ATF's supply-side strategy. In 1996, the ATF initiated the Youth Crime Gun Interdiction Initiative (YCGII) with commitments from 17 cities to trace all recovered crime guns (ATF, 1997). This program expanded to 55 cities in 2000 (ATF, 2002). Other jurisdictions have also expanded their use of gun tracing; six states, for example, have adopted comprehensive tracing as a matter of state policy, either by law (California, Connecticut, North Carolina, and Illinois), by executive order (Maryland), or by law-enforcement initiative (New Jersey) (ATF, 2000b).

Comprehensive tracing of all firearm recoveries reduces some bias in trace data introduced by police decision making. Jurisdictions that submit all confiscated guns for tracing can be confident that the resulting database of trace requests is representative of a well-defined "population" of guns recovered by police during a particular period of time and a reasonable "sample" of guns used in crime (Cook and Braga, 2001). Using recovered crime guns, as a basis for estimating the characteristics of all guns used in crime, is analogous to using arrestees as a basis for estimating the characteristics of all criminals. Although both are unrepresentative of the relevant populations in various ways and both are influenced by police priorities and procedures, the validity of the conclusions drawn from these data depends on the application and the care that is taken to provide appropriate qualifications (Cook and Braga, 2001). Trace data have been

used in several policy evaluations, including studies to determine the impact of Virginia's law limiting handgun purchases to one per month on Virginia's role in supplying guns to New York and Massachusetts (Weil and Knox, 1996), the effects of the Brady Handgun Violence Prevention Act on interstate gun-trafficking patterns for crime guns recovered in Chicago (Cook and Braga, 2001), the impact of the 1994 assault weapons ban on gun markets (Koper and Roth, 2001), and the effects of reforms to the federal firearms licensing system on criminal gun suppliers (Koper, 2002).

BOSTON FIREAMS TRACE DATA

The ATF's Boston Field Division was among the pioneers of a comprehensive approach, tracing all guns recovered by the Boston Police Department beginning in January 1991 (Kennedy et al., 1996). Between January 1991 and December 2003, trace requests for 8,058 handguns were submitted to the NTC. Most handguns were recovered in illegal gun possession crimes (64.9% or 5,228 handguns). Substantive crimes, such as homicide, assault, and robbery, accounted for 22.4% (1,806) of the handgun recoveries, and the remaining handguns were recovered in other or unknown circumstances (12.7% or 1,024 handguns). Overall, 38.8% (3,128) of the handguns were recovered from youth aged 24 years and under. Of these trace submissions, 48.8% (3,930) were successfully traced to the first retail purchaser. The 51.2% of trace requests that failed did so for a variety of reasons. Ten percent of the guns (809) were not successfully traced because they were too old,[5] and another 16.1% (1,298) failed because the serial number was obliterated. Most remaining unsuccessful trace requests failed because of error on the submission forms or problems obtaining the information from the FFL that first sold the gun at retail.

In this analysis, the age of recovered handguns was based on the results of the ATF trace and by considering whether a trace was not successful because of age. The ATF's standard definition of a fast time-to-crime firearm as being recovered within three years or less of its first retail sale (ATF, 2002) was used to categorize a recovered handgun as a "new" or "older" firearm. Therefore, if a traced handgun was recovered in crime within 36 months of its first retail sale, it was coded as a new handgun. If a traced handgun was recovered in crime after 36 months of its first retail sale or the handgun was not traced because it was too old, it was coded as

5. Firearms manufactured before the Gun Control Act of 1968 were not required to be stamped with a serial number. During the mid-1990s, the ATF made a series of policy decisions on tracing older guns. In June 1994, the ATF decided not to trace guns manufactured before 1985, and in March 1995, the ATF decided not to trace guns manufactured before 1990. The results of these trace requests were coded as "too old to trace" (Kennedy et al., 1996). These policy decisions were reversed, however, in June 1996 when the YCGII program was launched.

an older handgun. Including "too old to trace" firearms in our categorizations of age removes the bias toward overstating the prevalence of new guns associated with standard ATF analyses of time-to-crime of recovered crime guns (see Cook and Braga, 2001). Using this coding scheme, age categories were assigned to 58.8% (4,739) of the handguns recovered in Boston between January 1991 and December 2003. For each of the 156 months during this time period, the monthly percentage of new handguns, for all recovered handguns where an age category could be determined, was calculated.

The Ceasefire intervention was generally focused on disrupting the supply of all new handguns to criminals in Boston. However, because the Boston Gun Project was focused on reducing youth violence, new handguns recovered from youth offenders were given top investigative priority by participating law-enforcement agencies. Given this focus on illicit youth acquisitions of new handguns recently purchased in the primary market, it is possible that any significant reduction in the supply of new guns would be concentrated only in the portion of Boston's illegal market serving youths rather than manifested in a generalized across-the-board reduction in the availability of new guns to all offenders in Boston. A corollary and important issue is whether less versus more serious consumers of illicit handguns have different patterns of acquisition and, therefore, are less vulnerable to a supply-side strategy focused on new guns sold in the primary market. If serious offenders use handguns that are older, the impact of a trafficking enforcement strategy focused on close-to-retail diversion would not be very powerful on the availability of guns to this high-risk population. As such, the effects of Operation Ceasefire's supply-side interventions on new handguns recovered in Boston were analyzed based on four key outcome variables: the monthly percentage of total handguns recovered that were new, the monthly percentage of handguns recovered from youth that were new, the monthly percentage of handguns recovered in illegal gun possession crimes that were new, and the monthly percentage of handguns recovered in substantive crimes that were new.

ANALYTIC STRATEGY

The four key outcome variables were interval measures that were generally distributed in the shape of a normal distribution.[6] Therefore, we

6. Kolmogorov–Smirnov tests for goodness of fit were used to investigate the significance of the difference between the observed distributions and a normal distribution (Kanji, 1993). We failed to reject the null hypothesis that there is no difference between the distribution of the data set and a normal distribution for all dependent variables except percent substantive crime guns with fast time-to-crime. The distribution of this variable had a moderate positive skew (0.70). OLS regression, however, is robust to modest violations of assumptions of normality and remains an appropriate method to

modeled the effects of Operation Ceasefire on the recovery of new handguns in Boston by using ordinary least-squares (OLS) linear regression models.[7] As noted, the Ceasefire intervention was considered to be fully in place as of May 15, 1996 (Braga et al., 2001; Kennedy et al., 2001). However, it is unlikely that the supply-side strategy had an immediate effect on the stockpile of handguns already in criminal hands. Most fast time-to-crime handguns recovered by the Boston Police immediately after the implementation of Ceasefire had been diverted from retail outlets before the program was in place. Any reductions in the prevalence of new handguns would be detected later as the mixture of illegal handguns on the street changed. Therefore, we measured the impact of Ceasefire on the percentage of recovered handguns that were new in Boston at a one-year lag. For convenience, we therefore begin the "post" period on June 1, 1997 and estimated the effect of the intervention by using a dummy variable (0 = intervention not present, 1 = intervention was present). The pre-intervention time series was composed of monthly key outcome measures between January 1991 and May 1997; the intervention time series was composed of the monthly key outcome measures between June 1997 and December 2003.

In any time series, three sources of noise could obscure intervention effects: trend, meaning the series could drift upward or downward; seasonality, meaning the series could spike at different times (e.g., gun recoveries could increase in the summer months); and random error, meaning that even if the series was detrended and deseasonalized, observations would fluctuate around some mean level (McDowall et al., 1980, p. 14). If a time-series model does not account for these sources of error, the intervention analysis will be confounded. To account for existing trends in the series, we included a simple linear trend variable and a nonlinear trend variable in our models.[8] Dummy variables for each month were also included in the models to account for seasonal effects in the time series.

The general class of autoregressive integrated moving average (ARIMA) models can be used to good effect in detecting existing sources of noise in a time series (McDowall et al., 1980). We used ARIMA models

analyze these interval data (Blalock, 1979). Therefore, we did not transform the variable to smooth the distribution into an exact normal curve.

7. Two-limit tobit models are sometimes applied in situations where the outcome variable is a probability or a percentage (Long, 1997). However, in our analyses of the distributions of the dependent variables based on percentages, values did not cluster at 0, 100, or any other minimum or maximum value. Therefore, truncation issues did not limit the dependent variables.

8. The trend variable was simply the month number from the start to the end of the time series (i.e., for January 1991 through December 2003, the trend variable ranged from 1 to 156). The nonlinear trend variable was the square of the trend variable.

to unravel the error structure in the pre-intervention time series for each outcome measure to guide us in accounting for these sources of error in our OLS regression models.[9] In particular, we were interested in determining whether a nonseasonal autoregressive component needed to be estimated in our regression models. The ARIMA analyses revealed that none of the time series data showed significant serial autocorrelation (i.e., monthly figures for all outcome measures were not serially correlated).[10] Therefore, we did not include a nonseasonal AR(1) autoregressive component in our models.

Beyond the error inherent in the structure of time series data, our estimate of the effects of Ceasefire on the recovery of new guns recovered in Boston could be confounded by several other factors. These potentially confounding factors are discussed briefly here. The monthly number of violent gun crimes (homicide, assault, and robbery) could influence the demand for new guns. If the streets are violent, criminals and gang-involved youth may feel a heightened risk of violent victimization and seek out handguns for protection. Increased enforcement actions against gun-using criminals and illegal gun traffickers could increase the number of handguns recovered and, because of the focus on new guns, artificially inflate our estimates of new handguns over time. Over the course of the 1990s, the ATF's ability to successfully trace recovered firearms improved steadily (Cook and Braga, 2001; Pierce et al., 2004). The improved ability of the ATF to trace guns and determine the age of guns could influence our measures of the monthly percentages of new handguns recovered of the course of the time series. Finally, implemented in February 1994, the Brady Handgun Violence Prevention Act required FFLs to conduct a

9. We pursued these analyses to ensure that we were accounting for possible sources of error in our OLS regression models and did not use ARIMA models to measure intervention effects. Identifying appropriate ARIMA models for evaluation purposes can be a very subjective exercise. As Gary Kleck (1997) suggests, "Experts in ARIMA modeling also commonly point out the difficulties that even experienced practitioners have in specifying time series models. Specification is very much an art rather than a science, so that different researchers, using the same body of data, can make substantially different, even arbitrary decisions, and, as a result, obtain sharply different results" (p. 354).

10. Using a variety of ARIMA specifications, we did not detect any statistically significant nonseasonal autocorrelation in the time series data for the four key outcome measures. For example, using an ARIMA (1,1,1)(1,1,1) model, we estimated an AR(1) = –0.123 ($p = 0.542$) for the monthly percentage of total handguns that were new handguns, an AR(1) = –0.205 ($p = 0.292$) for the monthly percentage of youth handguns that were new handguns, AR(1) = 0.175 ($p = 0.379$) for the monthly percentage of illegal possession handguns that were new handguns, and AR(1) = 0.086 ($p = 0.541$) for the monthly percentage of substantive crime handguns that were new handguns. The findings of our ARIMA analyses of the pre-intervention time series are available on request from the authors.

criminal background check on all prospective handgun buyers. Although Massachusetts already required criminal background checks, the passage of the Brady Law may have limited the ability of gun traffickers to purchase firearms in loose control states that previously did not require background checks to acquire new handguns. Therefore, we included the following control variables in our model: the monthly number of violent gun crimes in Boston, the monthly number of handguns recovered in Boston, the monthly percentage of recovered handguns for which an age could not be determined, and a dummy variable indicating the passage of the Brady Law (0 = Brady Law not enacted, 1 = Brady Law enacted). Inserting the percentage of total recovered handguns that were new as the dependent variable, the basic model was as follows:

Monthly Percent New Handguns = Intercept + Lagged Intervention + Trend + Trend-squared + Monthly Number of Violent Gun Crimes + Monthly Number of Handguns Recovered + Monthly Percentage of Recovered Handguns w/o Age + Brady Law + Month Dummy Variables + Error

We also conducted an exploratory analysis of trends in ATF firearms trace data for other major U.S. cities that engaged comprehensive tracing programs for all recovered crime guns. It is important to assess whether any changes in the percentage of new handguns recovered in Boston were associated with a distinct treatment effect or reflective of a nationwide trend in the availability of new guns to criminals. During the 1990s, the Clinton Administration made a concerted effort to reduce criminal access to guns by supporting the passage of the Brady Law in 1993 and a partial ban on assault weapons in 1994 Violent Crime Control and Law Enforcement Act, increasing the screening, regulation, and licensing fees of federally licensed gun dealers in 1993, and with the launch of the YCGII program in July 1996, it put more federal resources into crime gun tracing and investigating gun traffickers (Cook and Braga, 2001). Unfortunately, Boston was the only U.S. city that comprehensively traced all recovered firearms before the ATF launched its YCGII program in 1996. As such, it is not possible to compare pretest and post-test trends in Boston with other cities. However, post-test trends in the monthly percentage of handguns that were new can be examined in 14 YCGII cites for January 1996 through December 2003.[11] Post-test-only designs with nonequivalent control groups are obviously limited by the absence of pretest measurements;

11. Although 17 cities (16 cities plus Boston) originally participated in the YCGII program, two of these original cities stopped participating in the program during our study time period. Inglewood, California stopped participating in 1999 and Bridgeport, Connecticut stopped participating in 2000 (ATF, 2000b; 2002). Therefore, 14 YCGII cities were included in our exploratory analyses of crime gun trends between 1996 and 2003.

therefore, any post-test differences between the groups can be attributed either to a treatment effect or to selection differences between the different groups (Cook and Campbell, 1979). Our analysis of post-test trends is simply intended to explore whether gun market trends in Boston, on face value, seem to be different from gun market trends elsewhere in the United States.

Similar to the measurement problems experienced during the developmental years of the Federal Bureau of Investigation's Uniform Crime Reports program (see, e.g., Schneider and Wiersema, 1990), YCGII firearms trace data in specific cities suffered from some early methodological problems that limit our ability to conduct within-city analyses of monthly trends in the age of recovered guns. Most notably, certain cities did not consistently record the recovery date for crime guns, and instead, the date of batch trace requests was used to calculate time-to-crime for crime guns without a specific recovery date.[12] Although the impact on time-to-crime estimates is minimal, monthly recovery figures are problematic because a specific month cannot be reliably assigned to guns without a recovery date. These problems were corrected in 1999 when the ATF instituted a data quality accountability system and provided additional funds to assist local police departments manage the firearms tracing process (ATF, 2000b). Therefore, for individual YCGII cities, we conduct simple analyses of yearly trends in the percentage of recovered handguns that were new and, for aggregated YCGII cities, use OLS regression analysis, controlling for the monthly number of trace submissions, percentage of recovered guns with an undetermined age, and seasonal variations, to examine changes over time in monthly trends in the percentage of recovered handguns that were new.

RESULTS

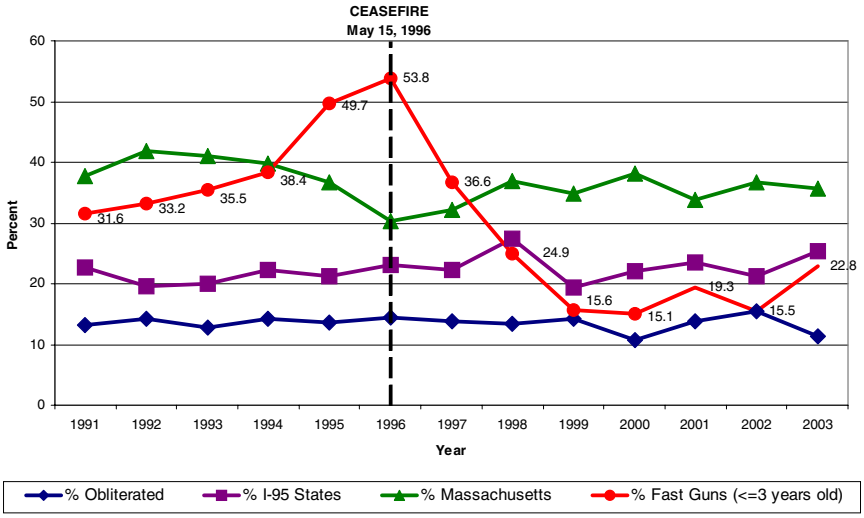
TRENDS IN THE CHARACTERISTICS OF BOSTON CRIME HANDGUNS

Figure 2 presents yearly trends in four key characteristics of handguns recovered in crime by Boston Police between 1991 and 2003. The

12. This problem was discovered when the monthly counts of handgun recoveries in specific cities were found to be unusually uneven across consecutive months. Aggregate monthly counts of handgun recoveries for all 14 YCGII cities, however, did not exhibit an unusually uneven distribution. According to Special Agent Terry Austin, Director of the ATF NTC, certain cities initially struggled with timely submission of trace requests and properly filling out the required trace paperwork. Most cities made batch trace requests to the NTC on a monthly basis so time-to-crime figures were, at worst, one month too short or one month too long depending the date of the actual recovery and the date the batch trace request was made to the NTC.

Ceasefire intervention apparently had a large impact on the yearly percentage of traceable handguns recovered by the Boston Police that were new. However, Ceasefire gun market disruption strategies had no impact on the source states from which traceable handguns were first purchased and no influence on the percentage of crime handguns with obliterated serial numbers. The percentage of newer handguns steadily increased from 31.6% of traced handguns with a fast time-to-crime in 1991 to a peak of 53.8% of traced handguns with a fast time-to-crime in 1996. Between 1997 and 1999, the percentage of traced handguns with a fast time-to-crime decreased dramatically to 15.6% and remained at this lower level through 2003. Counting 1997 as the first full year of gun market intervention, there was a 47% reduction in the percentage of new traced handguns in Boston from a mean of 40.4% between 1991 and 1996 to a mean of 21.4% between 1997 and 2003.

FIGURE 2. KEY CHARACTERISTICS OF HANDGUNS RECOVERED IN BOSTON, 1991–2003



The yearly percentage of traced handguns originating from FFLs in Massachusetts and from FFLs in the loose-control southern "I-95" states remained relatively stable between 1991 and 2003. This stability is not surprising because the intervention focused on illegal diversions of new guns from both intrastate and interstate sources. The age of the guns, not the location of the source, was the trigger for enforcement action. New guns were prevalent in investigations of trafficked guns originating in Massachusetts and from other states. New guns were trafficked in 48.7% of the 184 investigations involving intrastate-only diversions, 64.5% of the 111

investigations involving interstate-only diversions, and 67.7% of the 75 investigations involving both interstate and intrastate diversions.

The percentage of recovered handguns with obliterated serial numbers, a clear indicator of gun trafficking, was also stable between 1991 and 2003. It suggests that the obliteration of serial numbers by gun traffickers remained a method to avoid detection over the course of the Ceasefire intervention. Trained firearms examiners, however, can sometimes restore obliterated serial numbers and traces of guns with obliterated serial numbers can then proceed. The Boston Police Department restored the serial numbers for 410 obliterated serial number firearms between 1995 and 2003 (45.1% of 910 obliterated serial number guns). The ATF Boston Field Division resubmitted these guns for tracing and examined the time-to-crime of these formerly obliterated firearms.[13] For guns recovered in 1995 and 1996, the ATF reported that 47.6% of restored guns were new. In contrast, for guns recovered between 1997 and 2003, the ATF reported that only 21.6% of restored guns were new. As will be discussed, this evidence suggests that, in reaction to a law-enforcement strategy focused on new guns, gun traffickers substituted older guns for high-risk new guns.

MULTIVARIATE ANALYSES OF NEW HANDGUNS RECOVERED IN BOSTON

Table 2 presents the results of the OLS regressions on the lagged effects of Operation Ceasefire on the four key outcome measures. The effects of Operation Ceasefire were manifested in a generalized across-the-board reduction in the availability of new guns to all offenders in Boston. For all dependent variables, the implementation of Operation Ceasefire, at a year lag, was associated with statistically significant reductions in the percentage of recovered handguns that had a fast time-to-crime.[14] Holding other predictor variables constant, Ceasefire was associated with a statistically significant 22.7% reduction in the mean monthly percentage of all recovered handguns that were new, a statistically significant 24.3% reduction in

13. These data were provided by the ATF Boston Field Division from their Obliterated Serial Number Project, a special initiative to better focus their enforcement efforts on guns that were most likely to be trafficked.

14. When the intervention dummy variable was not lagged by one year, the coefficients still revealed varying reductions in the percentage of fast time-to-crime guns for the four outcome measures. Holding other predictor variables constant, Ceasefire was associated with an 8% reduction in the mean monthly percentage of all recovered handguns that were new, a 6% reduction in the mean monthly percentage of all recovered youth handguns that were new, an 18% reduction in the mean monthly percentage of illegal possession handguns that were new, and a 3% reduction in the mean monthly percentage of all recovered substantive crime handguns that were new. These weaker reductions suggest that Operation Ceasefire had a small immediate effect on new guns in the hands of criminals that strengthened as time passed.

the mean monthly percentage of all recovered youth handguns that were new, a statistically significant 29.7% reduction in the mean monthly percentage of illegal possession handguns that were new, and a statistically significant 17.4% reduction in the mean monthly percentage of all recovered substantive crime handguns that were new. The Durbin–Watson test of the residuals from the regression analyses indicated that first-order serial correlations did not exist in the models.[15] Relative to handguns recovered in illegal possession crimes, handguns recovered in substantive crime were somewhat less vulnerable to a trafficking enforcement strategy focused on new guns sold in the primary market. It is possible that these guns were older because substantive crime offenders may have a "tools of the trade" outlook toward weapons and, therefore, are more likely to keep and use older guns (Kennedy et al., 1996). Nevertheless, even with these higher risk individuals, a gun market disruption strategy remains a logical pursuit.

Controlling for other predictor variables, the monthly number of violent gun crimes did not have a statistically significant effect on the monthly percentage of recovered handguns that were new for any of the four outcome measures. Reductions in the monthly percentage of recovered handguns with a fast-time-to-crime were from the implementation of Ceasefire rather than from monthly changes in Boston gun violence. Controlling for other predictor variables, the enactment of the Brady Law was associated with varying increases in the monthly percentage of new handguns recovered. The increased presence of new handguns after the passage of the Brady Law is likely to be a spurious relationship. The Brady Law dummy variable captured some of the increasing saturation of new guns on Boston streets between 1994 and 1996 that was fueled by the demand of Boston youth for "new in the box" semiautomatic pistols during the early to mid-1990s (Figure 1).

ANALYSES OF THE AGE OF CRIME HANDGUNS IN COMPARISON CITIES

As discussed, it is possible that the large decrease in the percentage of recovered handguns that were new in Boston was part of a nationwide downward trend in the availability of new guns to criminals rather than a distinct program effect. In 14 YCGII comparison cities, however, the yearly percentage of traced handguns with a fast time-to-crime did not vary much after the adoption of Ceasefire in Boston (Table 3). In 1996,

15. According to Pyndick and Rubinfield (1991), the Durbin-Watson test ranges from 0 to 4. First-order serial correlation does not exist when the Durbin–Watson statistic is close to 2.

TABLE 2. OLS REGRESSIONS OF THE EFFECTS OF OPERATIONS CEASEFIRE AT A ONE-YEAR LAG ON THE MONTHLY PERCENTAGE OF HANDGUNS WITH FAST TIME-TO-CRIME RECOVERED IN BOSTON, JANUARY 1991–DECEMBER 2003

	Percent Total Handguns		Percent Youth Handguns		Percent Possession Handguns		Percent Crime Handguns	
Variable	B (S.E.)	*t*	B (S.E.)	*t*	B (S.E.)	*t*	B (S.E.)	*t*
Ceasefire (1-year lag)	–.227(.040)	–5.65***	–.243(.065)	–3.714***	–.297(.050)	–5.905***	–.174(.083)	–2.086*
Trend	.001(.002)	.285	–.001(.003)	–.159	.001(.002)	.203	.002(.004)	.432
Trend-squared	–.000006(.000)	–.281	–.000002(.000)	–.137	–.000005(.000)	–.417	–.00001(.000)	–.711
N violent gun crimes	.000(.000)	1.00	.000(.001)	.229	.000(.001)	.328	.001(.001)	.951
N handguns rec'd	–.002(.001)	–2.29*	–.003(.002)	–1.18	–.001(.001)	–.886	–.002(.001)	–1.31
% handguns w/no age	.182(.094)	1.93	.008(.153)	.055	.295(.118)	2.497*	–.030(.196)	–1.53
Brady Law enacted	.106(.048)	2.27*	.131(.079)	1.66	.104(.060)	1.731	.111(.099)	1.115
January	.039(.044)	.898	–.070(.071)	–.993	.046(.055)	.837	–.061(.091)	–.671
February	–.042(.044)	–.956	–.044(.071)	–.615	–.037(.055)	–.685	–.024(.091)	–.265
March	–.012(.044)	–.283	–.067(.071)	–.950	–.018(.055)	–.325	–.011(.091)	–.121
April	.041(.045)	.914	–.046(.071)	–.644	.026(.056)	.470	.092(.093)	.992
May	.038(.045)	.859	.048(.072)	.668	.025(.056)	.439	–.024(.093)	–.261
June	–.002(.043)	–.039	.014(.070)	.204	–.032(.054)	–.583	.007(.090)	.078
July	.043(.043)	1.020	.043(.069)	.626	.020(.053)	.366	–.035(.089)	–.390
August	.024(.044)	.536	–.122(.070)	–1.759	.016(.055)	.285	–.070(.091)	–.771
September	.107(.043)	2.47*	.127(.070)	1.819	.096(.054)	1.773	.059(.090)	.655
October	–.020(.042)	–.482	–.034(.069)	–.493	–.031(.053)	–.592	–.009(.088)	–.106
November	.029(.043)	.666	–.024(.070)	–.346	.027(.054)	.510	–.064(.089)	–.724
Intercept	.253(.135)	1.88	.467(.225)	2.08*	.259(.169)	1.535	.253(.280)	.904
N	156		156		156		156	
R-square	.599		.411		.565		.261	
F-test	11.346***		5.308***		9.882***		2.687***	
Durbin-Watson test	1.74		2.00		1.99		1.82	

NOTE: December is the reference category for the month dummy variables.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

27% of recovered handguns were new; the yearly percentage of new handguns decreased slightly to a low of 22.6 in 1999 and then increased back to 26.8% in 2003. Table 4 presents the results of an exploratory analysis of the monthly percentage of traced handguns with fast time-to-crime in all 14 YCGII cities between January 1996 and December 2003. Controlling for seasonal variations and trace submission characteristics, the OLS regression model did not reveal any significant downward linear or nonlinear trends in the monthly percentage of fast time-to-crime guns in other YCGII cities during the study time period.

TABLE 3. YEARLY TRENDS IN PERCENT HANDGUNS WITH FAST TIME-TO-CRIME IN BOSTON AND 14 YCGII CITIES, 1996–2003

City	1996	1997	1998	1999	2000	2001	2002	2003
Boston, MA	53.8	36.6	24.9	15.6	15.1	19.3	15.5	22.3
YCGII, total	27.0	23.7	23.3	22.6	25.0	23.4	24.8	26.8
Atlanta, GA	36.9	35.6	41.6	48.7	40.7	37.6	33.4	31.9
Baltimore, MD	26.5	25.8	23.9	24.3	18.0	20.2	18.2	17.2
Birmingham, AL	35.9	33.3	27.8	28.1	26.3	29.6	32.9	32.8
Cleveland, OH	29.9	25.7	23.7	22.9	25.6	22.4	21.4	24.1
Jersey City, NJ	15.9	27.9	21.1	21.3	26.9	21.2	26.8	24.1
Memphis, TN	N/A	18.2	25.9	30.7	31.9	34.2	31.1	30.5
Milwaukee, WI	35.3	40.0	27.8	46.3	39.1	35.7	31.0	32.7
New York, NY	21.1	16.0	16.5	17.3	20.7	20.7	21.3	18.7
Richmond, VA	43.2	43.8	47.9	33.3	34.4	35.8	34.9	33.1
Salinas, CA	26.9	19.8	33.3	25.0	19.1	9.7	20.7	20.9
San Antonio, TX	26.9	33.3	18.9	21.3	23.6	24.5	27.5	25.2
Seattle, WA	26.7	23.4	25.9	30.4	38.4	27.4	26.1	24.2
St. Louis, MO	17.5	16.3	15.3	15.8	12.1	10.7	11.0	12.3
Washington, DC	21.4	23.0	20.8	11.8	16.6	21.4	18.3	21.1

The analyses of aggregated YCGII data could mask noteworthy city-level downward trends in the percentage of recovered handguns that were new were similar to Boston. Unfortunately, as discussed, more formal statistical modeling based on monthly trends in recovered percentages of new handguns could not reliably be completed at the city level of analysis. Based on the limited available data, Table 3 suggests that no other YCGII city experienced a similar large decrease in the yearly percentage of new traced handguns. Certain cities, such as Baltimore (MD), Richmond (VA), and St. Louis (MO), experienced moderate decreases in the yearly percentage of new traced handguns over time. The passage of laws limiting retail purchasers to one handgun a month in Maryland and Virginia may have contributed to the decline in newer crime guns in Baltimore and Richmond. It is also not surprising, however, to observe some modest downward trends in the percentage of recovered handguns that were new

TABLE 4. OLS REGRESSION FOR TRENDS IN THE MONTHLY PERCENTAGE OF HANDGUNS WITH FAST TIME-TO-CRIME IN 14 YCGII CITIES, JANUARY 1996–DECEMBER 2003

Variable	B	S.E.	*t*	Sig.
Constant	.314	.030	10.38	.000***
Trend	–.001	.000	–1.58	.118
Trend-squared	.000006	.000	1.81	.076
Number of trace submissions	–.00005	.000	–3.577	.001***
Percent guns with undetermined age	–.044	.086	–.513	.609
January	.009	.012	.772	.442
February	.012	.012	.993	.324
March	.020	.012	1.696	.094
April	.010	.012	.842	.402
May	–.001	.012	–.120	.904
June	.009	.012	.747	.458
July	.00005	.012	.004	.997
August	.006	.012	.502	.617
September	–.001	.012	–.098	.922
October	.020	.012	1.721	.089
November	.002	.012	.208	.836

N = 96.
R-square = .29.
F = 2.181**.
Sig. F = 0.014.
Durbin–Watson test = 1.71.
NOTE: December is the reference category for the month dummy variables.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

in cities that participated in an ATF-sponsored anti-gun-trafficking program. Although these data must be interpreted with caution, the impact of the Operation Ceasefire gun market disruption program on new handguns seems to be both larger and of a different character than either secular trends or deliberate supply-side interventions operating in other cities.

DISCUSSION AND POLICY IMPLICATIONS

The results of this evaluation suggest that Operation Ceasefire's focus on close-to-retail diversions of handguns was associated with statistically significant decreases in the percentage of handguns recovered by the Boston Police that were new. Although data on street prices of new handguns paid by criminals were not available, the evaluation findings suggest that the supply-side enforcement strategy increased the "effective price" of new handguns by making it riskier to acquire these firearms for illegal possession and criminal use. Importantly, the results provide some much needed research evidence that supply-side strategies can be used to good

effect in shutting down direct pipelines of illegal guns to criminals.[16]

These results also support the growing evidence on the value of problem-oriented policing in dealing with crime problems (Braga, 2002; Eck and Spelman, 1987; Goldstein, 1990; Skogan and Frydl, 2004; Weisburd and Eck, 2004). Problem-oriented policing holds great promise for creating a strong response to illicit firearms markets (Pierce et al., 2004). This adaptable and dynamic analytic approach provides an appropriate framework to uncover the complex mechanisms at play in illicit firearms markets and to develop tailor-made interventions to disrupt the gun trade. The complexity and diversity of illegal gun markets suggests that there is no best policy or approach to disrupting the illegal supply of guns across the numerous jurisdictions in the United States. We believe that jurisdictions interested in reducing the availability of guns should develop a portfolio of interventions based on problem-solving partnerships among federal, state, and local authorities. By analyzing the nature of particular gun-trafficking problems, law enforcement can develop a systematic plan to shut down supply lines rather than simply pursuing ad hoc enforcement actions on specific individuals.

This research study did not attempt to determine whether the supply-side strategy reduced the existing stockpile of guns already in criminal hands or resulted in a net reduction in the general availability of guns to criminals.[17] As noted, the evaluation findings suggest that Boston criminals substituted older handguns for newer handguns in response to the gun market disruption strategy. The analog to the significant decrease in the monthly percentage of recovered handguns that were new was a

16. As suggested by one anonymous reviewer, Ceasefire's impact on youth gun crime may have had some unmeasured impact on the demand for new guns by youth. Although it seems possible that safer streets could reduce youth demand for guns, post-test-only data from the comparisons cities suggest that it is unlikely that any reduced demand was only manifested in the prevalence of new guns (Table 3). New York City, for example, experienced dramatic decreases in violent crime over the course of the 1990s. However, as Table 3 documents, the prevalence of new guns among recovered crime guns did not substantively change in response to safer streets. It strengthens the case that the marked decrease in the percentage of new guns observed in Boston was primarily because of a supply-side effect rather than some demand side influence.

17. Isolating the effects of the gun market disruption strategy on prospective dependent variables is a complex exercise that requires additional research. For example, the monthly number of gun recoveries, as a measure of changes in the number of guns in criminal hands, is influenced by gun enforcement actions and, therefore, confounded by the Ceasefire intervention. Analyzing changes in the monthly percentage of violent crimes committed with guns is also problematic. Any observed reductions in the percentage of violent crimes in Boston committed with guns could be indicative of a reduction in gun use associated with the pulling levers focused deterrence strategy rather than a change in the prevalence of guns in criminal hands associated with a supply-side effect.

significant increase in the monthly percentage of recovered handguns that were old. The ATF Boston's exploratory analysis of trace data associated with formerly obliterated serial number guns further documents a switch in trafficked firearms from new guns to old guns. It suggests that some gun traffickers sought to avoid detection by diverting older, secondhand guns recently purchased through primary and secondary market sources. The research cannot, however, determine whether the increased percentage of older handguns was driven primarily by substitution to recently purchased secondhand handguns, substitution to increased street trade in older handguns already present in the existing stockpile of guns in criminal hands, or some blend of these and/or other illegal sources of older firearms.[18]

The substitution from new handguns to older handguns suggests that Boston law-enforcement agencies need to focus their attention on alternative sources of firearms such as illegal diversions of secondhand guns from retail outlets and unregulated transfers from secondary market sources such as unlicensed dealers selling guns at gun shows and flea markets. The potential for substitution is precisely the reason that developing new crime intelligence methodologies to analyze local gun markets is key to improving the capacity of local jurisdictions to respond to illegal gun trafficking (Pierce et al., 2004). If proven methodologies exist to identify pathways of gun trafficking, law-enforcement agencies can reassess the situation, diagnose the alternative supply channel, and implement a response to reduce the flow of guns to the street. It fits well with the problem-oriented policing philosophy and advances a key component of the process—the analysis of problems.

Finally, our evaluation does not provide policy makers with any firm evidence on whether supply-side enforcement strategies have any measurable impacts on gun violence. A stand-alone trafficking prevention intervention would not face these difficulties and could lead to definitive answers on the impact of supply-side interventions on gun violence. Operation Ceasefire, however, was not a stand-alone trafficking prevention intervention. We believe that the principal impact on Boston youth homicide and nonfatal serious gun violence in the 1990s was nearly certainly a

18. Previous research found Boston youth did not acquire guns from household burglaries (Kennedy et al., 1996). It seems unlikely that there was a noteworthy substitution to older guns that were recently stolen from private residences. According to FBI UCR data, burglary decreased in Boston from 5,052 in 1996 to 3,830 in 2002. Moreover, the prevalence of household gun ownership in Massachusetts is very low. Burglary would be a relatively futile gun acquisition strategy. In 1995, the year Boston Gun Project research was conducted, only 15% of adults in Massachusetts reported having a gun in their home compared with 41% of adults nationwide reporting having a gun in their home (see http://www.mass.gov/dph/bhsre/isp/wrisp/pubs/wiupdate/97update/wriss03.htm).

demand-side, deterrence-based effect, rather than a supply-side effect. It may well be that anti-trafficking efforts strengthened and prolonged that impact. Whether any such effects were large or small could not be independently established in this case. However, it is noteworthy that, once the pulling levers strategy was discontinued, Boston youth gun homicide increased from 15 in 2000 to 36 in 2004. Newer handguns have become less prevalent on Boston streets, but through substitution to older handguns, guns remained available to criminals who demanded them. The level of youth gun crime in Boston may be more powerfully influenced by the ability of criminal justice agencies and their community-based and social service partners to respond to cycles of street gang violence. Clearly, more research is needed on the effects of supply-side enforcement strategies on the workings of illegal gun markets, the availability of guns to criminals, and the use of guns in violent crime.

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